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On the nature of the stellar bridge between Leo IV and Leo V

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Abstract.
We present a revised analysis of a speculated stellar bridge between the Milky Way dwarf galaxies Leo IV and Leo V. Using data acquired with Subaru/Suprime-Cam over a $1^\circ \times 4^\circ$ field encompassing the two satellites and the region in between, we confirm our previous detection of a stellar overdensity between Leo IV and Leo V (de Jong et al. 2010). The larger area coverage and improved depth of our current dataset allow for an improved analysis of the stellar overdensity that had previously appeared to bridge the two galaxies. A main-sequence turn-off feature visible in the stacked colour-magnitude diagram of the contiguously observed Subaru fields reveals an extended stellar structure at a distance of approximately 20 kpc. Its angular proximity to the Virgo overdensity, as well as a good correspondence in distance and metallicity, suggests that the smaller structure we detect may be associated with the much larger Virgo stellar overdensity.

1. Introduction

The discovery of numerous dwarf galaxies through the Sloan Digital Sky Survey (SDSS) over the last decade has helped to advance our understanding of the Milky Way in a cosmological context, with our appreciation of the Galaxy as a micro-cosmos, together with our ever-growing understanding of the Andromeda galaxy, leading to the development of 'near-field cosmology'. The constellation that boasts the largest number of Milky Way satellites is the realm of Leo, and two of its five dwarf-galaxy inhabitants form the subject of our current study. Discovered by Belokurov et al. (2007b, 2008), Leo IV and Leo V are close neighbours not just in projection — separated on the sky by a mere 3° — but also spatially, sharing residence of the Galactic halo beyond 150 kpc. Targeted observations for studying these Milky Way satellites and their surrounding environment by de Jong et al. (2010) using the LAICA imager on the 3.5m telescope

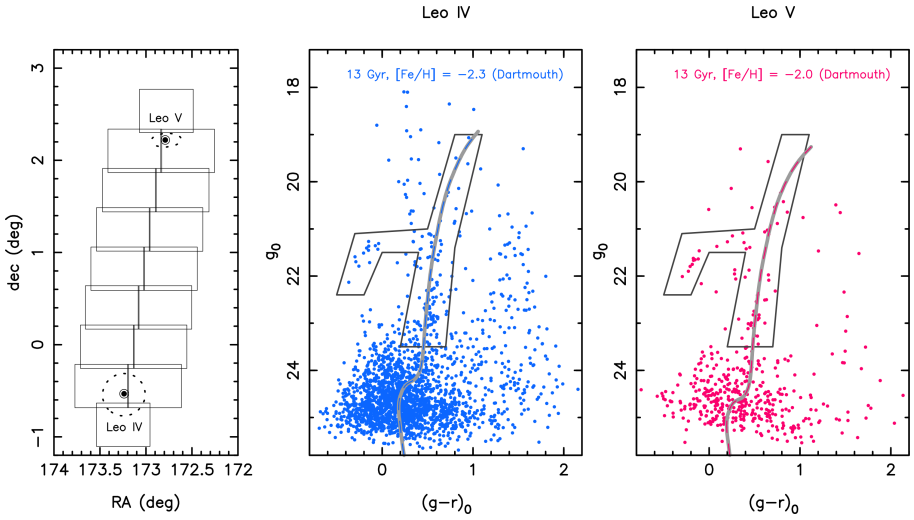

Figure 1. Left panel: footprint of the observed Subaru fields. Locations of the individual Subaru/Suprime-Cam fields are shown, together with dotted ellipses marking 4 half-light radii of Leo IV and Leo V. Middle panel: colour-magnitude diagram of stars within 2 half-light radii of Leo IV, overlaid with a 13-Gyr Dartmouth isochrone with [Fe/H] = −2.3 dex. The delineated section (same in both CMDs) is used as a selection box for avoiding Leo IV and Leo V members when exploring the question of a stream's presence within the Subaru fields. Right panel: as for middle panel but for Leo V; the isochrone has been altered to reflect the metallicity differences in the Leo IV and Leo V stellar populations.

at the Calar Alto observatory led to the unexpected detection of an overdensity of stars, seemingly bridging the two galaxies. However, the loss of one of three planned fields due to bad weather unfortunately left us with only a tentative detection of the possible stellar bridge, whose true nature unfortunately could not be resolved from these data alone. Follow-up observations using Subaru/Suprime-Cam aimed at obtaining a wider and deeper dataset has enabled us to shed clearer light on the nature of this stellar overdensity, as well as allowing for an improved set of structural parameters to be derived for Leo IV and Leo V. These results are presented in summarised form in this contribution, with full details to be presented in a paper currently in preparation.

2. Structural parameters of Leo IV and Leo V

Altogether, 16 Subaru/Suprime-Cam fields were used to obtain a wide coverage of Leo IV, Leo V, and their surrounding environment. Figure 1 provides an overview of the location of the observed fields, as well as the colour-magnitude diagrams (CMDs) of the two Leo systems; the data have been photometrically calibrated field-by-field to the SDSS, and extinction-corrected following the Schlegel et al. (1998) dust maps. The updated structural parameters, derived using a maximum-likelihood procedure as described by Martin et al. (2008), are summarised in Table 1.

Parameter	Leo IV	Leo V
R.A. (J2000)*	$11^{\rm h}32^{\rm m}58.1^{\rm s}$	$11^{\rm h}31^{\rm m}08.3^{\rm s}$
Dec. (J2000)*	$-00^\circ32'11.2''$	$02^\circ13'20.9''$
θ (deg)*	5^{+45}_{-45}	30^{+15}_{-22}
ϵ*	$0.03^{+0.18}_{-0.03}$	$0.15^{+0.34}_{-0.15}$
$r_{\rm h}$ (arcmin)*	$2.3^{+0.3}_{-0.4}$	1.8 ± 0.5
D (kpc)	154 ± 5	175 ± 9

Table 1. Structural parameters of Leo IV and Leo V (*updated using the current dataset); from top to bottom: centroid position, position angle, ellipticity, half-light radius and heliocentric distance (Moretti et al. 2009; de Jong et al. 2010).

3. Positioning the stellar stream: near or far?

Despite the improved depth and coverage of the Subaru data with respect to our earlier dataset, we identified no clear spatial overdensity indicative of a distant stellar stream in our new dataset. However, a CMD of the data from all 16 Suprime-Cam fields, with stars belonging to the dwarf galaxies removed, shows a feature resembling a main-sequence turn-off at $g_0 \sim 20$ mag (see Figure 2). Its location and profile are well matched by a 13-Gyr-old stellar population roughly 20 kpc away with [Fe/H] of approximately -1.6 dex when compared with Dartmouth isochrones (Dotter et al. 2008).

As can be seen from the Milky Way's 'field of streams' (Belokurov et al. 2007a), the stellar overdensity lying on top of Leo IV and V is found near a region of the sky occupied by several prominent streams and stellar overdensities. Given its currently understood properties and angular separation from the Sagittarius stream, an association of the newly detected structure with Sagittarius is unlikely. A connection with the nearby Virgo overdensity is in fact more probable, given a close agreement in distance and metallicity (e.g., Duffau et al. 2006; Jurić et al. 2008). Whatever its allegiance, the stars once thought to possibly be associated with the Leos are clearly not occupants of the distant halo, but more likely members of a structure enjoying inner-halo residency.

4. Summary

Using deep Subaru/Suprime-Cam data, we have obtained an improved set of structural parameters for the Milky Way dwarf galaxies Leo IV and Leo V. Additionally and more interestingly, we find that a tentative stream of stars previously detected between the two dwarfs is part of a more extended stellar overdensity, coincidentally overlapping the satellite galaxies. Previously taken as a hint of a feature related to the dwarf galaxies, the deeper and wider Suprime-Cam data reveal a main-sequence turn-off in the stacked CMD consistent with that of a 13-Gyr-old stellar population with [Fe/H] of -1.6 dex at a distance of approximately 20 kpc.

While being far enough away from the multiple wraps of the imposing Sagittarius stellar stream to avoid this affiliation, the on-sky proximity of the stellar overdensity enveloping Leo IV and Leo V to the Virgo stellar overdensity, along with a comparable distance and consistent metallicity, appears to imply an association with the latter structure. Indeed, our former Leo stellar-bridge hopeful appears to be suffering a constellation membership crisis. Instead of being trapped inside the lion's den, however,

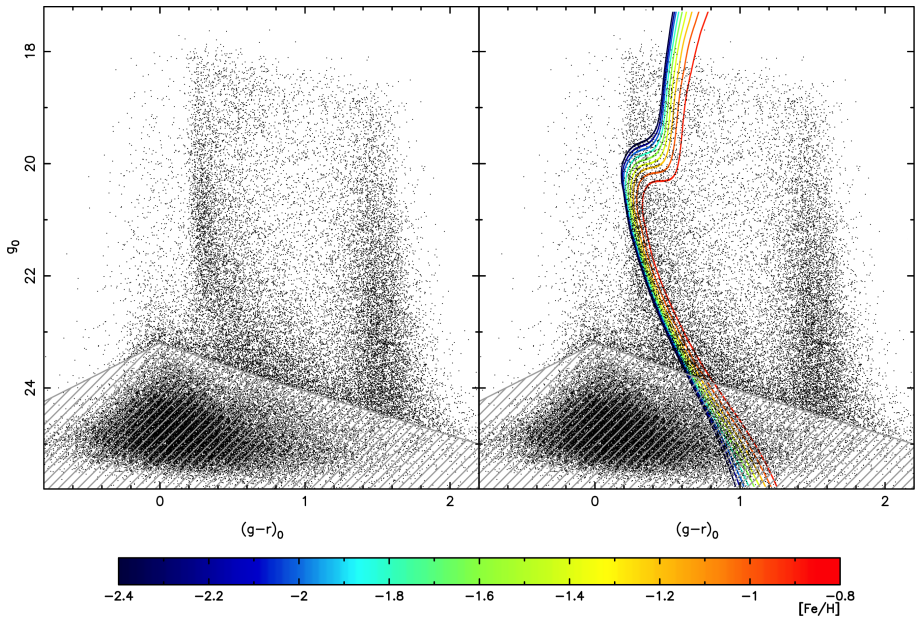

Figure 2. Left panel: stacked CMD of all stars within the Subaru fields. Stellar contributions from Leo IV and Leo V have been removed by designating an elliptical exclusion region with a semi-major axis of 4 half-light radii for each galaxy, together with the selection box shown in Figure 1. The grey shaded region is expected to contain mainly galaxy contamination; only one in four data points have therefore been plotted. Right panel: as in left panel, but with 13-Gyr Dartmouth isochrones of different metallicities (Dotter et al. 2008) overlaid to roughly match the location of the main-sequence turn-off feature.

the stars of the newly detected stellar substructure manage to escape the Leos' jaws, only to be lured into the arms of Virgo.

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